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BLM's remote sensing program in Utah

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The BLM's Remote Sensing Program in Utah

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Abstract

The objective of this paper is to outline the Bureau of Land Management's Remote Sensing Program in the state of Utah, including its evolution, structure, present and planned projects, and goals for the future. The paper will also address the challenges of establishing a new technology in the federal government and will offer viable solutions to these challenges.

BACKGROUND

Role of the Bureau of Land Management

The Bureau of Land Management (BLM) is functionally located in the U.S. Department of the Interior. BLM manages one-eighth of the nation's lands, which is roughly 270 million acres nationwide, and has the largest natural resources base under federal control, including the responsibility of managing the subsurface minerals. Most of the lands managed by BLM are located in the Western United States, although small parcels are scattered across the Eastern United States. In Utah the BLM manages 22 million acres of public land, which is approximately 42 percent of Utah's land base.

The BLM is responsible for the balanced management of the public lands and resources and their various values so that they are considered in a combination that will best serve the needs of the American people. Management is based upon the principles of multiple use and sustained yield, a combination of uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources. BLM manages to obtain an ecologically sound environment for a variety of multiple uses. The managed resources include range, timber, minerals, watershed, fish and wildlife, with BLM considering wilderness and natural, recreational, scenic, scientific, and cultural values.

The BLM has many long-term goals that include the following: BLM will improve resource conditions and prevent environmental degradation so that the public lands serve as a model for environmentally sound land-use management; BLM will strengthen research, science, and technical development efforts to accommodate the growing emphasis on global environmental issues and to incorporate proven technological developments into its program practices; and BLM will foster a service ethic that is responsive to the public and that meets the needs for public participation and information sharing.

BLM's Remote Sensing Program in Utah

The remote sensing program for BLM in Utah is located within the Automated Cartography Section of the Mapping Sciences Unit in the Division of Operations. The specific responsibilities of remote sensing include aerial photography flight planning, project coordinating, and contracting; photogrammetric applications for road updates, site plans/engineering work, contouring, and resource inventory; resource mapping utilizing satellite imagery and aerial photography; implementation of new technologies, i.e., videography; participation in the development and use of digital orthophotographic coverage; and training in remote sensing principles to other BLM employees.

Because BLM is concerned with multiple land-use management, this offers a wide variety of applications in remote sensing.

ESTABLISHING A NEW TECHNOLOGY

Overview of Identified Applications and the Remote Sensing Program

BLM's remote sensing program has taken a long time to become a reality. Prior to its being established, efforts were made for five years to acquire image-processing capabilities. Pilot projects were completed at universities to demonstrate the value of remote sensing as a resource tool, and ground work was laid for the eventual implementation of the program.

Because BLM is a conservative organization and does not have a large budget with which to work, getting people interested in remote sensing required the identification of potential remote sensing users within the BLM. Due to the nature of multiple land use in BLM, there was a diversity of operations and land-use applications. Because of this diversity, remote sensing was an attractive tool for many land-use specialists and managers.

The initial step in developing a viable remote sensing program within the "multiple use" concept was to identify several reasonable applications for the technology with potentially strong remote sensing supporters. This step was where major efforts were focused. The identified remote sensing applications are shown in Figure 1. Following identification of the applications, digital image-processing capabilities were achieved through the acquisition of a Sun

IDENTIFIED APPLICATIONS:	
- *FIREFUELS*	- *CIVIL ENGINEERING / SITE PLANS*
- *CHANGE DETECTION*	- *HAZARDOUS MATERIALS*
- *VEGETATION MAPPING*	- *WILDLIFE HABITAT*
- *SOILS MAPPING*	- *LAW ENFORCEMENT*
- *RECREATION*	- *ROAD INVENTORY*
- *ARCHAEOLOGY*	- *OHV MAPPING*
- *RIPARIAN*	- *MAP UPDATES*
- *MINING / MINERALS*	

Figure 1

workstation, Earth Resource Data Analysis System (ERDAS) image-processing software, GRASS image-processing software, and Land Analysis System (LAS) image-processing software. At this point, a projected "remote sensing program" was outlined. A two-year projection is shown in Figure 2. Initially, training and setup of the hardware/software system were the major focus along with continued identification of proven applications. Over time, training lessened significantly and identification of proven applications moved into production, verification, and promotion. These proven applications continued over time, with many projects to be completed/updated on an annual basis. Midway through the first year of program implementation, new applications were defined. These new applications were then sorted for feasibility. Viable new applications were then tested and evaluated with a reasonable pilot project. Promising pilot projects then went into production, were quality checked, and were distributed to the users. The projection for implementation of the entire program was two years. According to the trend to date, however, the program has moved much more rapidly. The program initiated in September 1991 was at about the program's one-year target goal in April 1992.

The program identified two types of projects: proven projects and new ideas/sampling. These project types are illustrated in Figure 3.

Proven projects go through a production phase and are then distributed. Projects that represent new, unproven ideas are evaluated, tested, evaluated again, and then produced if reliable results are obtained.

Challenges in Establishing a New Technology

Many challenges were met in establishing the remote sensing technology. The first and largest challenge by far was the issue of having to work with a limited budget. Establishing any new technology at the BLM must be cost-effective. Having the field and resource specialists convinced of the benefits in implementing remote sensing as a new technology without being given an initial budget to do so made the initial purchase of the hardware/software configuration very difficult. Although some research and development were done in each project, the primary emphasis was to be productive and cost-effective. Therefore, the second challenge was balancing research and development with actual production demonstrating proven benefits. The third challenge was educating the users of remote sensing products about the growing potential of the new technology, stressing that field work not be eliminated but better directed through the use of remote sensing. Finally, meshing the new technology within the existing framework of hardware and software configurations was difficult. Problems were encountered in trying to interface the Sun workstation with the Prime computer, BLM's standard computer. Problems also arose with interfacing the image-processing software with MOSS software, BLM's standard software. Possible difficulties were expected initially, but challenges were fully realized as projects were worked on. For example, a typical three-step process for plotting took about ten steps to complete.

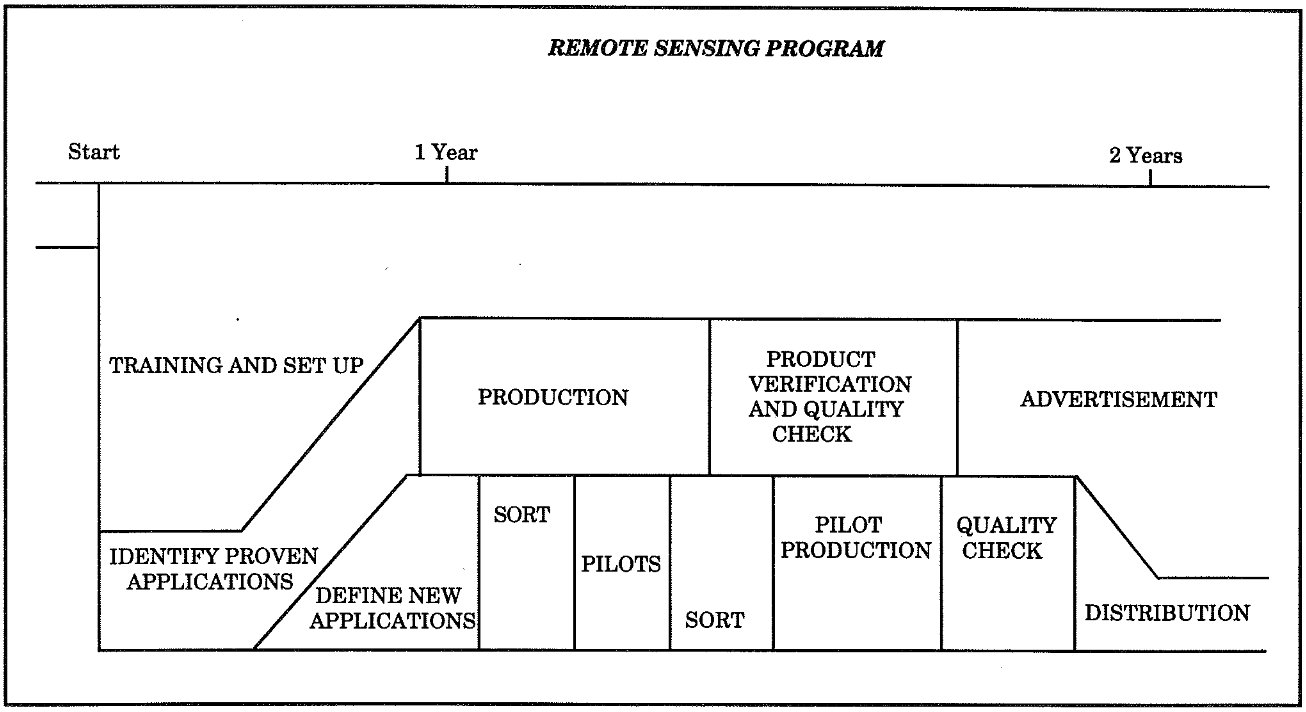

Figure 2

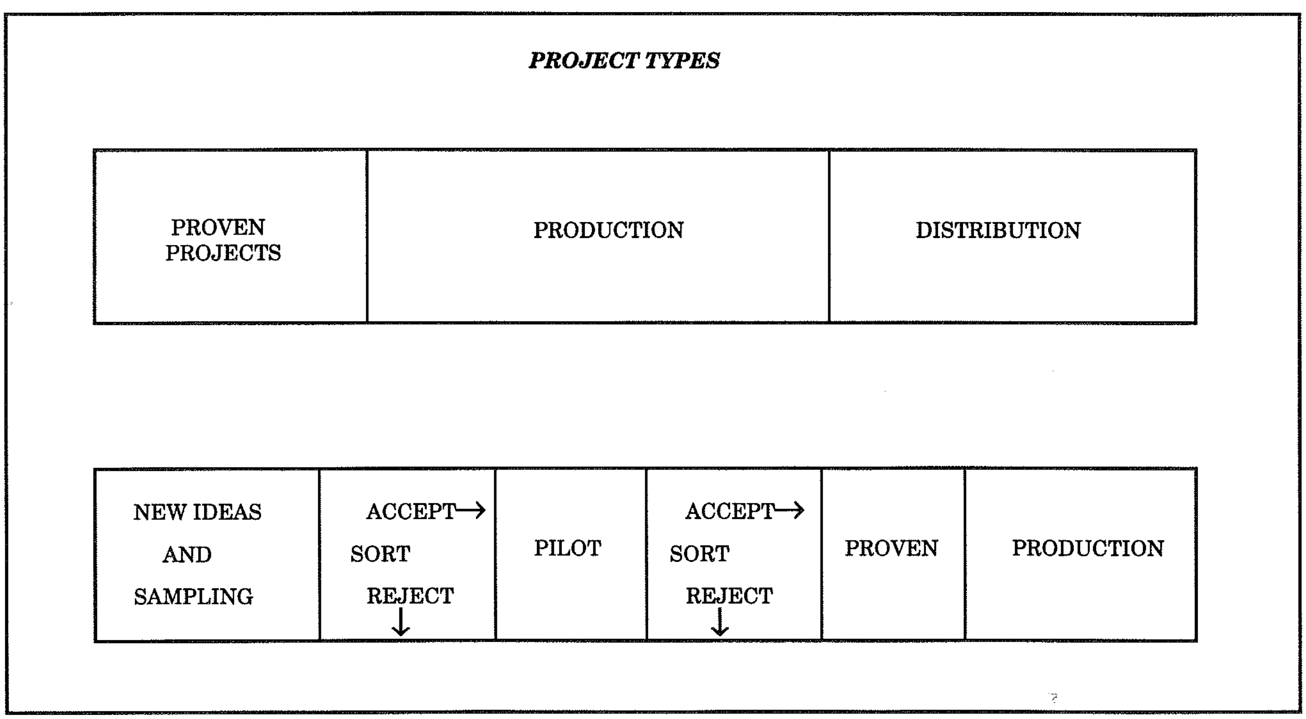

Figure 3

Identified Solutions to the Challenges

The initial challenge of having a limited budget with which to purchase an appropriate hardware/software configuration was overcome through purchase made solely by one user based on the demonstrated performance of remote sensing techniques for law-enforcement applications. The second challenge of balancing research and development with actual production will be accomplished through cooperative identification of applications with known applications and success. This is being currently demonstrated with a firefuels vegetative-cover map being produced using AVHRR data, which is based on a similar regional project done at BLM's Service Center in 1985. Once production begins, it is expected that other applications with high potential will be identified. Solutions to this challenge also include involvement with other organizations outside of BLM on a cooperative basis, with pilot projects exploring new applications. Current plans for cooperative project work include videography for riparian monitoring, law enforcement, and range-resource inventory; geological applications for structure identification and hazardous materials inventory/monitoring; map updates via digital orthophotos; Gap Analysis and other vegetative studies; soils mapping; wildlife-habitat monitoring; and change detection with older scanned imagery and new sources. Cooperative ventures are attractive because as development occurs technology is exchanged among the participants.

The solution for educating field and resource specialists in the benefits of using remote sensing as a tool will be a multitactic approach. Plans include developing hard output products and soft demos for demonstrations in-house and in the field. A newsletter will also be generated on a quarterly basis to relay technology updates as they occur. There will be personal briefings to specific state office users and potential users. Displays of output will be prepared for district and resource area offices. Finally, training classes will be presented on the field applications and user involvement in ground truthing. An important consideration that cannot be stressed enough is not to oversell the technology. It is imperative to develop and communicate a long-range plan for project development. This plan and any modifications that may have to be made as the project progresses need to be clear to all involved parties.

The final challenge of meshing the new technology within the existing framework of hardware and software can be solved by identifying current and projected needs for hardware and software. A primary source of this knowledge is through the BLM Service Center as a cooperative education venture. Additional identification of future needs can come from interaction with in-house computer support staff. A final note on this, based on lessons learned, is that anyone setting up a new remote sensing system needs to take careful consideration of various hardware/software interactions and to find out all information regarding compatibility. Types of storage media also need to be considered carefully. An example of this consideration is whether to invest in a system that supports 8-mm tapes versus 9-track tape formats. The remote sensing unit at BLM currently houses an 8-mm tape drive as well as a CD-ROM drive. Computer support staff currently use only a 9-track tape drive. To be able to utilize certain equipment, data transfers from one media to another have had to be addressed, which can be time consuming and can cause delays in production. Media choices are costly; therefore, careful preplanning is important.

PRESENT AND PLANNED PROJECTS OF THE REMOTE SENSING PROGRAM

Since the remote sensing program got under way in September of 1991, careful planning has gone into cost-effective projects. The following is a summary of some of these projects.

AVHRR Firefuels Project

The firefuels project is currently under way, utilizing AVHRR imagery. Figure 4 summarizes the objectives, advantages, and disadvantages of the firefuels project.

This project is based on a regional firefuels map BLM's Service Center did in 1985. AVHRR imagery is acquired from approximately 500 NOAA-11 images consisting of twenty-one fourteen-day maximum Normalized Difference Vegetation Index (NDVI) composites. The pixel resolution is 1 km. The data for

AVHRR FIREFUELS PROJECT

OBJECTIVES:
- *ANNUAL UPDATE*
- *CHANGE DETECTION*

ADVANTAGES OF AVHRR IMAGERY
- *COST-EFFECTIVE*
- *CLOUD-FREE IMAGERY*
- *MULTIDATE COVERAGE*

DISADVANTAGES OF AVHRR IMAGERY:
- *COARSE RESOLUTION*

Figure 4

each pixel in the composite are extracted from the daily observation scene on the basis of the maximum NDVI compositing process. Compositing AVHRR data acquired over several days produces spatially continuous cloud-free imagery over large areas with sufficient temporal resolution to study green-vegetation dynamics. There are two satellite overpasses per day, one in the Eastern and one in the Western United States. Every image that provides a clear observation of a large ground surface area at reasonable nadir viewing angles for the two-week compositing period is included in the composite. Generally there are about eighteen daily observations included in the two-week composite.

Image-to-image registration is done through a base image for reference. The base image is the USGS 1:2,000,000 Digital Line Graph (DLG). The DLG is rasterized to 1 km cells and registered to the Lambert Azimuthal Equal Area (LAZEA) map projection. Image processing is accomplished utilizing both the LAS and ERDAS image-processing software.

Presently, the NDVI data set for Utah has been subset from the United States database. Each observation period in the data set was then combined into a single composite image.

Once composited, the image was enhanced using Principal Components Analysis (PCA). Image enhancement is the process of making an image more interpretable for a particular application. Enhancement can make important features of raw, remotely sensed data more interpretable to the human eye. Enhancement techniques are often used for extracting useful information from images. Principal Components Analysis is an enhancement technique in which the number of image file bands can be reduced and new bands created to account for the most variance in the data.

The bands of PCA data are noncorrelated and independent and are often more interpretable than the source data. The first principal component corresponds to the major axis of the ellipse of data distribution.[1] This defines a new axis, and points in the scatterplot are given new coordinates that correspond to the new axis. Therefore, new data file values are derived from this process. These values will be stored in the first principal component band of a new data file. The first principal component measures the highest variation within the data.

The second principal component is perpendicular to the first principal component. The second principal component describes the largest amount of variance in the data that is not already described by the first principal component. Each successive principal component is the widest transect of the ellipse that is perpendicular to the previous components. It also accounts for a decreasing amount of the variation in the data that is not already accounted for by previous principal components.

In PCA, the first few bands account for the highest proportion of variance in the data. Therefore, PCA is useful for compressing data into fewer bands. For the firefuels map, the first three principal component bands accounted for 92 percent of the total variance. These three bands were subset to form a single image. This image was then run through a classification program to create a map consisting of forty classes.

Another angle covered was to subset elevation data for Utah from the AVHRR digital elevation model files. The source of the AVHRR DEM data was the USGS 1:2,000,000 DLGs. The elevation data were then combined with the previously derived three principal component bands. Once these were combined to form a single image, it was classified into forty classes. It was determined that the elevation data would not be used initially because the classification using the three PCA bands appeared to be more detailed. This classification will then be overlaid with vector data (state boundary, county boundaries, major roads) for ground truthing.

The vector data files were originally in the Universal Transverse Mercator map projection. This vector data was transformed into the Lambert Azimuthal Equal Area Projection to match the raster base map.

This classification map will then be overlaid with the vector data mentioned previously. The vector data will aid in the ground-truthing process. Plans exist for incorporating elevation data into the data set if significant discrepancies exist in the class identifications. Once the initial classification map is ground truthed and final vegetation types assigned to the classes, the map will be dispersed to fire personnel as well as to resource specialists needing vegetation information.

Videography

The new technologies of airborne videography and global positioning systems (GPS) have been identified as valuable, cost-effective sources of imagery for the remote sensing program. Interest lies in both natural color videography as well as multispectral airborne videography. Future applications include work in riparian monitoring, law enforcement, range-resource inventory, and hazardous materials inventory/monitoring.

At the time the initial configuration for image processing was planned for and acquired, videography hadn't been introduced to the Utah state office. Plans are being made, however, to become heavily involved

[1]ERDAS Field Guide, Version 7.5, July, 1991, pp. 98-102.

in videography applications. Videography may become the primary source of imagery for the program. Currently, cooperative agreements are being established with other agencies and institutions for participation in videography programs. Future plans include eventually obtaining "video frame grabbing" software as soon as the program can be proven useful and cost-effective.

The above-mentioned situation that occurred with videography is an excellent illustration showing that as remote sensing programs are being established it is not always possible to identify all the needs in the beginning. New needs and changes are bound to present themselves after initial implementation. This is also true of hardware/software changes that occur in a rapidly evolving technology such as remote sensing.

Riparian Applications

Riparian-oriented applications have become increasingly important at BLM over the last several years. It is an area where inventory, mapping, and monitoring have become a priority for many projects. Therefore, riparian applications have been identified as a high-potential use for remote sensing techniques.

Work is currently being done on a riparian project at Horseshoe Springs in Skull Valley, Utah, involving airborne videography and global positioning systems (GPS) correlation. This project was initially going to be done in December 1991. However, inclement weather conditions forced the project to be postponed after all the arrangements were made and underway. The field work and videography were planned to be done the last week in April 1992.

There are several objectives in this project. The first objective is to map the vegetation in the area for wildlife biology purposes. Additional objectives involve some research and development in assessing airborne videography and GPS. In the past, standard field-gathering tools for the BLM have been base maps, compasses, and other required survey equipment. Base maps typically include the 7½-minute format, 1:24,000 scale maps, and the 1:100,000 base maps published by the BLM. GPS technology is now a reality; and at the federal government level, GPS technology is planned to be used extensively in the near future. The other objectives of this project are (1) to explore the practical uses of GPS, the accuracy of GPS mediums in relation to realistic ground locations, and the benefit to be realized by field personnel and resource specialists; (2) to integrate GPS technology with satellite imagery, traditional aerial photography, and base maps; and (3) to analyze and assess the uses and advantages of videography equipped with a GPS readout as a new technology for resource studies.

Data available for the project area prior to the GPS and videography field work include base maps (24 K and 100 K scales), aerial photography at a scale of 1:3,000, traditional survey data (sixteen points), and a Landsat TM scene. Techniques that will be analyzed in this project include a ground-based survey-grade GPS unit, an airborne GPS unit, airborne videography, and airborne 70 mm photography.

The project will focus on addressing the following issues:

1. What are the coordinate readings of selected ground points using GPS, base maps, survey data, and satellite imagery? How do they compare or differ and what are the relative accuracies between the methods being analyzed?

2. How/what technologies can be used in tandem to complement/supplement each other?

3. Is a GPS coordinate sufficient for field location or is a "buffer zone" necessary?

4. What are the uses, advantages, and applications of videography for resource work?

5. What is the accuracy of producing a one-foot contour map of the riparian area using the 70 mm photography on an AP190 stereo plotter versus the accuracy of utilizing the 1:3,000 existing photography employing traditional photogrammetric techniques and methods? This project will be done as a cooperative effort with the Forest Services NFAP office and is scheduled for completion in June 1992.

Other riparian projects slated for work in 1992 include vegetation inventory and monitoring of the riparian areas along the Green and Colorado Rivers.

Minerals Applications

Minerals inventory and monitoring, geological structure identification, and hazardous materials inventory are areas in the mining and minerals sciences that have been identified as areas of interest to remote sensing.

Work has begun on a uranium mining inventory that is mandated by Washington to be completed. Utah has approximately 17,000 uranium mines (both current and abandoned) that need to be inventoried and assessed. Remote sensing plans include a variety of pilot projects using techniques ranging from SPOT imagery and traditional aerial photography to airborne videography and GPS.

Soil Science Application

Soils mapping is another area of great interest to the BLM. Remote sensing work is currently being done in the Henry Mountain and Sagers Wash areas, utilizing Landsat TM imagery. Through the experimentation of certain techniques, such as band ratioing, soils mapping via remote sensing techniques may be a viable solution in the future.

Streambed Morphology

Streambed morphology is currently being analyzed for a length of the San Juan River in southern Utah to determine shifts in the riverbed over time. Side Looking Airborne Radar (SLAR) imagery is being used in this project. SLAR has a pixel resolution of 14 m. Both near-range and far-range formats are being evaluated. It is hoped that streambeds will be delineated structurally on the radar imagery. A variety of enhancements will be done on the imagery to obtain the best results.

THE FUTURE OF THE REMOTE SENSING PROGRAM

Due to the rapidly developing and changing technology in remote sensing, the future will be challenging and exciting. As the BLM continues to develop and grow in remote sensing, undoubtedly obstacles will be encountered that will have to be overcome and solutions will have to be derived to ensure cost-effectiveness as well as quality.

The role of interagency cooperative agreements will become increasingly attractive and valuable in terms of expertise and resource exchanges; and if proposed congressional legislation of Landsat imagery occurs, the cost of new imagery will be reduced significantly, enabling more research and development to occur. BLM has established several future objectives. These are listed in Figure 5.

Of great significance to many organizations will be the long-range focus on global condition, change, and monitoring issues.

CONCLUSIONS

If there is one major point to be made, it is that change is a good thing. In order to improve our capabilities and effectiveness, we must be able to be versatile and to welcome change. In this way, advancements and achievements are made.

FUTURE REMOTE SENSING OBJECTIVES

1. *BUREAUWIDE REMOTE SENSING CAPABILITIES*
2. *PHOTOGRAMMETRIC APPLICATIONS*
3. *RIGHTS-OF-WAY DETERMINATION*
4. *GLOBAL CHANGE ANALYSIS*
   - *TEMPORAL CHANGE / ENVIRONMENTAL MONITORING*
5. *MAPPING UPDATES*
6. *GLOBAL POSITIONING SYSTEMS (GPS)*
7. *CONSISTENT BUREAUWIDE STANDARDS*
8. *INTERAGENCY EXCHANGE OF SATELLITE IMAGERY VIA EOSAT AGREEMENTS*

Figure 5

Oftentimes, we tend to sit back and wait for others to provide direction and to create our destiny. We should not just sit back and wait for opportunities to come and find us, but we should go out actively looking for them. Remote sensing has been such a rapidly changing field over the past decade that it is important to keep our eyes open and to look for opportunities and new applications. There will be both successes and failures in remote sensing, and we can always learn and improve from both. A goal at BLM is to create a network with others in remote sensing and to generate a quarterly newsletter that gives a general summary on the types of applications on which individuals are working. That way we will not keep on "reinventing the wheel." We can draw on one another's expertise and benefit from one another's experiences. That is a solution that would benefit all who are concerned with the future of remote sensing.